

REVISED VERSION

(19) World Intellectual Property
Organization
International Bureau



(43) International Publication Date
10 June 2004 (10.06.2004)

PCT

(10) International Publication Number
WO 2004/049379 A3

(51) International Patent Classification⁷: **H01J 21/02**,
19/24, F25B 21/00, H01L 37/00

Leri [—/—]; c/o Borealis Technical Limited, Montagu
Pavilion, 8-10 Queensway, Gibraltar (GI).

(21) International Application Number:
PCT/IB2003/006484

(81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(22) International Filing Date:
27 November 2003 (27.11.2003)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
0227687.1 27 November 2002 (27.11.2002) GB

(84) Designated States (*regional*): ARIPO patent (BW, GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

(71) Applicant (*for all designated States except US*): **BOREALIS TECHNICAL LIMITED** [—/—]; Montagu Pavilion, 8-10 Queensway, Gibraltar (GI).

(72) Inventors; and

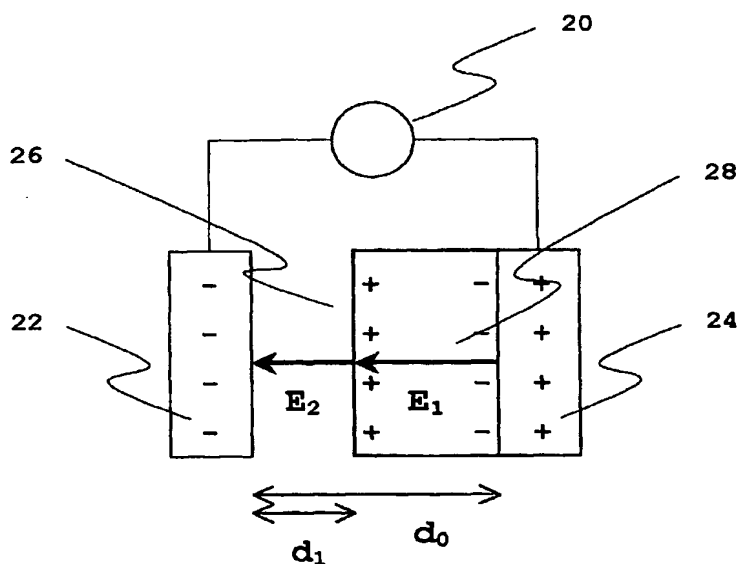
(75) Inventors/Applicants (*for US only*): **TAVKHELIDZE**, Avto [—/—]; c/o Borealis Technical Limited, Montagu Pavilion, 8-10 Queensway, Gibraltar (GI). **TSAKADZE**,

Published:

— with international search report

[Continued on next page]

(54) Title: METHOD FOR INCREASING EFFICIENCY OF THERMOTUNNEL DEVICES



(57) Abstract: The present invention comprises a tunneling device in which the collector electrode (24) is modified so that tunneling of higher energy electrons from the emitter electrode (22) to the collector electrode is enhanced. In one embodiment, the collector electrode is contacted with an insulator layer (28), preferably aluminum oxide, disposed between the collector and emitter electrodes. The present invention additionally comprises a method for enhancing tunneling of higher energy electrons from an emitter electrode to a collector electrode, the method comprising the step of contacting the collector electrode with an insulator, preferably aluminum oxide, and placing the insulator between the collector electrode and the emitter electrode.

WO 2004/049379 A3



(88) **Date of publication of the international search report:**
22 July 2004
**Date of publication of the revised international search
report:**
10 March 2005

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(15) **Information about Correction:**
see PCT Gazette No. 10/2005 of 10 March 2005, Section II

(19) World Intellectual Property
Organization
International Bureau



(43) International Publication Date
10 June 2004 (10.06.2004)

PCT

(10) International Publication Number
WO 2004/049379 A3

(51) International Patent Classification⁷: **H01J 21/02**,
19/24, F25B 21/00, H01L 37/00

(21) International Application Number:
PCT/IB2003/006484

(22) International Filing Date:
27 November 2003 (27.11.2003)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
0227687.1 27 November 2002 (27.11.2002) GB

(71) Applicant (for all designated States except US): **BOREALIS TECHNICAL LIMITED** [—/—]; Montagu Pavilion, 8-10 Queensway, Gibraltar (GI).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **TAVKHELIDZE**, Avto [—/—]; c/o Borealis Technical Limited, Montagu Pavilion, 8-10 Queensway, Gibraltar (GI). **TSAKADZE**, Lerl [—/—]; c/o Borealis Technical Limited, Montagu Pavilion, 8-10 Queensway, Gibraltar (GI).

(81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States (*regional*): ARIPO patent (BW, GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

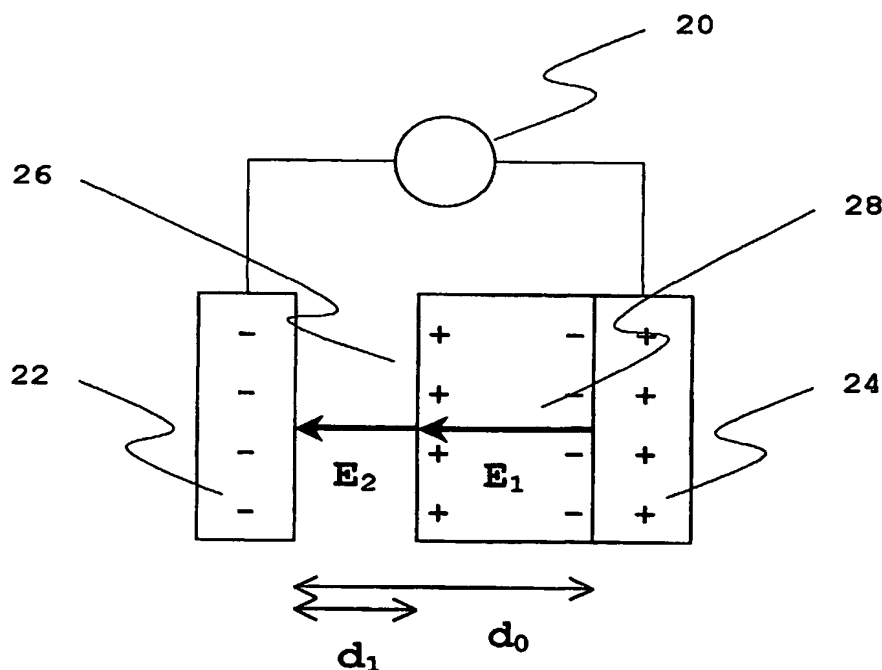
Published:

— with international search report

(88) Date of publication of the international search report:
22 July 2004

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: METHOD FOR INCREASING EFFICIENCY OF THERMOTUNNEL DEVICES



(57) Abstract: The present invention comprises a tunneling device in which the collector electrode (24) is modified so that tunneling of higher energy electrons from the emitter electrode (22) to the collector electrode is enhanced. In one embodiment, the collector electrode is contacted with an insulator layer (28), preferably aluminum oxide, disposed between the collector and emitter electrodes. The present invention additionally comprises a method for enhancing tunneling of higher energy electrons from an emitter electrode to a collector electrode, the method comprising the step of contacting the collector electrode with an insulator, preferably aluminum oxide, and placing the insulator between the collector electrode and the emitter electrode.

INTERNATIONAL SEARCH REPORT

International Publication No
P 03/06484

A. CLASSIFICATION OF SUBJECT MATTER IPC 7 H01J21/02 H01J19/24 F25B21/00 H01L37/00		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) IPC 7 H01J F25B H01L		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the International search (name of data base and, where practical, search terms used) EPO-Internal, INSPEC		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 99/10688 A (BOREALIS TECH LTD) 4 March 1999 (1999-03-04) abstract claims 1,7	1,6-8, 13-15, 20,21
X	US 3 169 200 A (HUFFMAN FRED N) 9 February 1965 (1965-02-09) column 2, lines 29-56; figure 2 column 3, lines 24-40; figures 2,3 column 4, lines 47-53 ----- -/--	1-3,6,7, 15,18-21
<input checked="" type="checkbox"/> Further documents are listed in the continuation of box C. <input checked="" type="checkbox"/> Patent family members are listed in annex.		
* Special categories of cited documents : <div style="display: flex; justify-content: space-between;"> <div> <p>*A* document defining the general state of the art which is not considered to be of particular relevance</p> <p>*E* earlier document but published on or after the international filing date</p> <p>*L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>*O* document referring to an oral disclosure, use, exhibition or other means</p> <p>*P* document published prior to the international filing date but later than the priority date claimed</p> </div> <div> <p>*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>*X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</p> <p>*Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>*G* document member of the same patent family</p> </div> </div>		
Date of the actual completion of the international search 11 March 2004		Date of mailing of the international search report 25/03/2004
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016		Authorized officer Reder, M

INTERNATIONAL SEARCH REPORT

Internat
P B03/06484

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	TAVKHELIDZE A ET AL: "Electron tunneling through large area vacuum gap — preliminary results" 2002, PISCATAWAY, NJ, USA, IEEE, USA, 25 August 2002 (2002-08-25), pages 435-438, XP010637519 page 435, left-hand column, lines 1-18 page 436, left-hand column, lines 27-35 page 438, left-hand column, lines 10-20	1-4,6,7, 15,16, 18-21
A	WO 99/13562 A (BOREALIS TECH LTD) 18 March 1999 (1999-03-18) cited in the application page 12, line 16 - page 14, line 9; figures 1,2 page 15, line 28 - page 17, line 3; figure 5	1-21
A	US 2001/046749 A1 (SKHILADZE GIVI ET AL) 29 November 2001 (2001-11-29) cited in the application paragraphs '0017! - '0024!; figures 1,2 paragraphs '0028! - '0030!; figure 5	1-21
A	HISHINUMA Y ET AL: "Refrigeration by combined tunneling and thermionic emission in vacuum: Use of nanometer scale design" APPL. PHYS. LETT. (USA), APPLIED PHYSICS LETTERS, 23 APRIL 2001, AIP, USA, vol. 78, no. 17, 23 April 2001 (2001-04-23), pages 2572-2574, XP002273205 ISSN: 0003-6951 the whole document	1-21

INTERNATIONAL SEARCH REPORT

International Application No
PCT/JP98/06484

Patent document cited in search report		Publication date		Patent family member(s)	Publication date
WO 9910688	A	04-03-1999	US	5722242 A	03-03-1998
			WO	9910688 A1	04-03-1999
			AU	4148597 A	16-03-1999
			EP	1009958 A1	21-06-2000
US 3169200	A	09-02-1965	CH	400269 A	15-10-1965
			GB	1003204 A	02-09-1965
			NL	294387 A	12-04-1965
WO 9913562	A	18-03-1999	AU	9225098 A	29-03-1999
			EP	1018210 A1	12-07-2000
			WO	9913562 A1	18-03-1999
US 2001046749	A1	29-11-2001	US	2002170172 A1	21-11-2002